MALARIA SECTION

OF THE

INTERNATIONAL CELEBRATION AND EXHIBITION

THREE HUNDREDTH ANNIVERSARY

OF THE FIRST RECOGNISED USE OF

CINCHONA BY EUROPEANS

1630-1930

AT

THE WELLCOME

HISTORICAL MEDICAL MUSEUM

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FOREWORD

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Malaria, cinchona bark, quinine and its other active principles are so closely connected in the public mind that a demonstration of this disease forms a fitting appendix to an Exhibition dealing with the history of cinchona.

The Malaria Section, which is taken from The Wellcome Museum of Medical Science, offers an example of what has been termed the synoptical method of museum demonstration. Here the disease is shown in all its aspects—historical, ætiological, pathological, clinical, therapeutic and preventive. It may be said to present a bird's-eye view of the whole subject.

The demonstration has been primarily designed for the use of medical students and for post-graduate study, as may be seen from the labels and descriptive text. The arrangement, however, is simple and can readily be followed by laymen who are interested in the subject.

In the short historical section, photographs of pioneers in malaria work are shown ; also a painting of the mosquito-proof hut in which Low and Sambon, at the instigation and under the direction of Sir Patrick Manson, carried out the classic experiment which confirmed the dictum " no mosquitoes, no malaria."

Paintings and photomicrographs show the various parasites responsible for malaria and the different phases in their life-history. The cycle in man and in the mosquito is clearly demonstrated in a series of diagrams, paintings and photomicrographs. The important part played by the mosquito in the genesis of malaria having thus been demonstrated, the structure, life-history and bionomics of this insect are illustrated in wax models, specimens and photographs. The mosquito breeds in water. There are four important types of breeding-places :—

1. Domestic (water tubs, tins on refuse heaps, defective gutters, etc.).
2. Ponds and streams.
3. Woodland.
4. Marshland.

Anti-malarial measures, like charity, must begin at home, but all or any of these breeding-places may play a part in the spread of malaria. Economy indicates an accurate knowledge of the bionomics of the species incriminated in any one district.

The pathology of the disease is demonstrated in a series of specimens, drawings, photographs and photomicrographs. Here will be noticed the characteristic enlargement of the spleen, the blocking of the small blood vessels of the brain by infected corpuscles, a similar condition in the intestinal capillaries and the vessels of the eye. Such specimens and pictures emphasise the gravity of the more severe forms of this disease, and the importance of rapid and effective treatment with quinine.

The clinical manifestations are shown in paintings and drawings. Here can be seen the grave anæmia which follows prolonged infection, the pigmentation of the skin which sometimes occurs, the protuberant bellies of native children whose spleens are enlarged as a result of chronic infection. Temperature charts are also exhibited, showing the relationship of the febrile condition to the various stages in the life-history of the parasite in the blood—thus, in a tertian fever sporulation occurs every 48 hours, producing a fever every other day; whereas, in a quartan fever, the sporulation occurs every 72 hours, producing a fever every third day.

In the treatment section are shown photographs of the culture of cinchona, also specimens illustrating the various stages in the preparation of quinine. The possible dangers of intramuscular injection are well demonstrated in specimens and photographs.

The prevention of malaria may be divided into three parts :—

1. Steps taken with regard to the sick person (treatment with quinine which kills the parasite, isolation by use of a mosquito net, etc.)
2. Steps taken with regard to the healthy individual (mosquito-proof houses, mosquito nets, protective clothing, prophylactic quinine, etc.)
3. Steps taken with regard to the mosquito :—
   (*a*) destruction of adults.
   (*b*) prevention of breeding by means of :—
      1. natural enemies
      2. drainage.
      3. draining of streams.
      4. use of oil or Paris green.

All these various methods are illustrated by numerous specimens, models and photographs.

The vast amount of work which has been carried out with regard to this one disease bears eloquent testimony to its importance in the development of tropical and sub-tropical countries.

December, 1930.

EXHIBITS FROM THE

WELLCOME MUSEUM OF MEDICAL SCIENCE

MALARIA SECTION

DESCRIPTIVE TEXT AND LABELS

I.—DISTRIBUTION

608. Map showing distribution.

609. Summary :—

A widespread disease, common in tropical and sub-tropical countries, caused by a non-cellular parasite—a protozoon—of the class *Sporozoa*, of the genus *Plasmodium*.

Three species of parasite have been incriminated—*Plasmodium malariæ*, *Plasmodium vivax* and *Plasmodium falciparum*. These parasites multiply asexually in the human blood and sexually in some mosquito of the genus *Anopheles*, these mosquitoes being essential for transmission from man to man. In the process of asexual development the various parasites present characteristic features by which they can be distinguished, the production of pigment being common to all. The ultimate product of schizogony is the merozoite, which infects fresh corpuscles and starts the cycle again. Eventually certain merozoites, instead of becoming schizonts, develop into gametocytes. The various stages of development both in the mosquito and man are clearly demonstrated in the accompanying illustrations.

Paroxysms of fever are said to coincide with the liberation of merozoites or spores, which thus determines the characteristic feature of the temperature chart. *Plasmodium vivax* causes tertian malaria, with a febrile paroxysm every 48 hours ; *Plasmodium malariæ* causes quartan malaria, with fever every 72 hours ; whilst *Plasmodium falciparum* causes malignant malaria, with an irregular chart.

Clinically, malaria is characterised by attacks of shivering, fever and sweating, accompanied in later stages by anæmia and enlarged spleen. In severe forms, practically any system may be affected, more especially the digestive and nervous. In malarious districts the inhabitants suffer from a chronic form of the disease.

In malaria the spleen and liver are enlarged, there is marked anæmia, blood changes are profound and characteristic, the complexion is sallow ; whilst in malignant malaria the small vessels of the brain or intestine may be blocked with infected corpuscles.

For *treatment*, reliance is placed on quinine and other cinchona products, which may be administered orally, intramuscularly, or intravenously.

Stovarsol has been found to be effective, especially in benign tertian infection. Plasmoquin Compound is of value, more especially against the gametocytes of malignant malaria.

Prevention depends upon supervision of the infected, the suppression of mosquitoes with elimination of breeding-places, and measures taken to safeguard the healthy population, such as mosquito nets or prophylactic quinine.

II.—HISTORY

Twelve Photographs are exhibited of pioneers in malaria work :—

610. Susruta. *Circa* 600 B.C.

Early Indian physician. In his writing, ascribed fevers to bites by mosquitoes.

611. Hippocrates. 460–377 B.C.

Greek physician, commonly known as "the Father of Medicine." Described accurately the clinical features of malaria and other tropical diseases.

612. Celsus. 25 B.C.–A.D. 45.

Roman physician and encyclopædist ; clearly distinguished two forms of malaria, and wrote on leprosy.

613. Galen. A.D. 130–200.

Greek physician and writer. Carefully described quartan and tertian malaria.

614. Morton, Richard. 1699–1730.

British physician and contemporary with Sydenham, with whom he was the first to introduce cinchona in the treatment of febrile conditions in England. Described epidemics of dysentery.

615. Beauperthuy, Louis Daniel. 1807–1871.

French physician. A great worker in the realm of tropical medicine, and one of the earliest advocates of the mosquito transmission theory for yellow fever and malaria.

616. Maillot, F. C. 1804–1894.

French physician and army surgeon. By his prophylactic work enabled the French to retain their hold on Algeria. Distinguished and classified the various tropical and sub-tropical fevers, and carried out much valuable work on the subject of malaria and its transmission.

617. Celli, Angelo. 1857–1914.

Italian physician. Celebrated for his work on tropical medicine, more especially on malaria.

618. Laveran, Charles Louis Alfonse. 1845–1922.

French physician and protozoologist. One of the great pioneers of Tropical Medicine. Professor at the Pasteur Institute, Paris. In 1880, discovered the parasite of malaria. Wrote classical treatises on malaria, leishmaniasis and trypanosomiasis.

619. Grassi. 1854–1925.

Proved that the development of the human malarial parasite in Anopheline mosquitoes followed Ross's cycle for bird malaria, and that these mosquitoes transmitted the disease from man to man.

620. Manson, Sir Patrick. 1844–1922.

Formulated the mosquito malaria hypothesis as a result of his work on filariasis and inspired Ross to put it to the test.

621. Ross, Sir Ronald. 1857–

Demonstrated the development of the parasites of bird malaria in mosquitoes, and their transmission by these insects. Traced the early stages of development of the human parasite in Anopheline mosquitoes and concluded that they would transmit.

622. Coloured Drawing of hut, where classical experiments by Low and Sambon were carried out.

623. Photograph of Sir Ronald Ross and Lady Ross at the Laboratory in Calcutta, where the original malaria-mosquito work was done in 1898-1899.

624. Two illustrations by Watson, showing the harm resulting from malaria invasion.

III.—ÆTIOLOGY

625. Summary :—

Malaria is caused by a protozoan parasite belonging to the class *Sporozoa*, whose definitive host is the *mosquito*, and intermediate host *man*.

Three species of parasite are recognised :—

Plasmodium malariæ—benign.

Plasmodium vivax—benign.

Plasmodium falciparum—malignant.

Laveran and, more recently, Grassi, have maintained that there is only one (polymorphic) species of parasite. This view is not generally accepted.

Malaria is spread from man to man by the Anophelini, a tribe of mosquitoes belonging to the sub-family Culicinæ ; up to the present no other mosquitoes have been found to act as hosts for the human parasite.

Among the many species known to carry malaria are included : *Anopheles maculipennis, Anopheles bifurcatus, Anopheles culicifacies,*

Anopheles costalis, Anopheles funestus, Anopheles ludlowi, Anopheles pseudopunctipennis, Anopheles albimanus, Anopheles pharoensis, Anopheles turkhudi, Anopheles superpictus and *Anopheles fuliginosus.*

Infection is liable to occur under any conditions which expose man to the bite of infected mosquitoes.

The association of breeding-grounds, human habitations and an infected native population provides all the necessary factors for a heavy local incidence. The importance of high temperature has long been recognised, but recently Gill has laid stress upon high relative humidity as a dominant factor in the development of the malarial parasite within the mosquito.

There are many varieties of mosquito breeding-grounds, which may conveniently be divided into :—

(1) Woodland, including water collection in tree holes, leaves, etc.

(2) Ponds and streams.

(3) Swamps, including flooded rice fields.

(4) Domestic and municipal, including barrels, broken guttering, wells, borrow pits, etc.

626. Three large paintings by Terzi are shown, illustrating *Anopheles maculipennis, Anopheles bifurcatus, Anopheles funestus,* and the three varieties of malaria parasites.

627. In a series of coloured drawings are shown the various forms of malaria parasite, the development of the parasite in the mosquito, and a number of breeding-grounds of this insect.

The benign tertian, quartan and malignant parasites are shown : (1) in their development from early rings to rosette forms, and (2) in their sexual forms as male and female gametocytes.

628. In three diagrammatic coloured drawings are represented the infection of the mosquito and the stages which ultimately lead to infectivity for the healthy individual.

629. Paintings of various breeding-places are shown :—

Forest pool with vegetable growth and absence of small fish.

Flooded rice fields.

A leaking irrigation channel, and badly-drained irrigated land.

Sand-banked pools left by a falling tropical river.

Type of Malayan hill stream. Breeding-place of a special species of Anopheline.

Forest breeding-places. Hollow tree trunks and branches, water-bearing agaves, cut bamboos, and *Nidularium ampullaceum.*

Anopheline pools, puddles and ditch in the insanitary roadway of a tropical town.

Mangrove swamp in the shallow portions of which Anophelines breed.

House at the base of a hill and adjacent to tropical swamp. Note faulty rain-gutter, unscreened barrel, pineapples which harbour water, and water-bearing epiphytes upon a tree.

Boat containing water collection and hoof-mark pools beside a tropical stream.

Shallow uncovered well. An infrequent breeding-place of Anophelines.

Water tank in tropical garden.

Flooded borrow-pits and water channel beside railway track.

630. A detailed description of the three species of malaria parasites :—

Plasmodium vivax (Grassi and Feletti, 1890).

Causes benign tertian malaria. Parasite requires 48 hours to complete asexual cycle. Attacks every third day. Sporozoites or merozoites approach red cell, indent it, and force way into stroma of corpuscle.

(1) Disc of cytoplasm with single nucleus.

(2) Vacuole appears, nucleus pushed aside. Very amœboid and active.

(3) Growth of parasite ; corpuscle enlarged, paler and containing Schüffner's dots.

(4) Continued growth, very irregular shape, numerous yellowish-brown pigment grains.

(5) Nucleus breaks up — chromatin granules forming chromatin of daughter nuclei. Typically 16 nuclei present (12–24).

(6) Parasite larger and practically fills corpuscle, which is now about 10 or 11 microns.

(7) Cytoplasm segments and merozoites are formed.

(8) Bursting of corpuscle. Pigment taken up by various leucocytes, large endothelial cells, etc.

(N.B.—After a mosquito has injected sporozoites, the initial attack of malaria occurs in 10–12 days ; *i.e.*, it requires five cycles to produce sufficient numbers to give rise to symptoms.)

After schizogony has been repeated several times, gametocytes appear —usually 10–14 days after initial attack.

The process of growth from merozoite to gametocyte takes place almost entirely in the vessels of the spleen or bone marrow, where the affected red blood corpuscles are held up. Amœboid action not marked. Corpuscles increase in size and Schüffner's dots develop. *Male :* pale cytoplasm, diffuse nucleus ; *female :* dense cytoplasm, compact nucleus. In both sexes pigment granules are scattered through the cytoplasm.

Supposed reproduction by Parthenogenesis. Schaudinn's theory is probably incorrect ; the condition described being the result of double infection of a cell by schizont and gametocyte *(see illustrations)*.

Plasmodium malariæ (Laveran, 1881).

Causes quartan malaria. Fever at intervals of seventy-two hours. Ring forms resemble those of *Plasmodium vivax*. Cytoplasm rather denser. Very little amœboid movement. Coarse and dark-coloured pigment granules. Organism tends to be stretched as a band across the corpuscle. Size of red blood corpuscle not increased, and may be darker in colour. No Schüffner's dots. Mature forms completely fill cell, pigment granules collected into central mass. About eight merozoites. During whole growth period the infected cells can be seen in the peripheral blood. Gametocytes are spherical bodies, completely filling the red blood corpuscles.

Plasmodium falciparum (Welch, 1897).

Causes malignant tertian malaria in man. Attacks irregular, often every alternate day or daily.

Very minute ring forms, many corpuscles parasitised—up to 25 per cent. Multiple infection of corpuscles. Chromatin granule projects beyond the margin of the ring. In many rings two chromatin granules may be present. "Bridge" and "marginal" forms very common. Growth of *Plasmodium falciparum* difficult to see, because infected cells are held up in the capillaries of internal organs, owing to tendency to clump together. They also tend to adhere to large mononuclear and probably endothelial cells *(see illustrations)*. Red corpuscles not increased in size, Maurer's dots occur, less numerous and more difficult to see than Schüffner's dots. The fully-formed schizont has a diameter of about five microns, and occupies only about two-thirds of the diameter of the corpuscle.

Nucleus multiplies. Merozoites 8–24 (average 16). Schizogony almost entirely in internal organs. Certain merozoites finally grow into gametocytes, which carry on further development in Anopheline mosquitoes. The gametocytes are crescentic or sausage-shaped. Nuclear and cytoplasmic differences as for *Plasmodium vivax*.

631. The various points are illustrated in a series of coloured drawings, which include the original paintings from Wenyon's "Protozoology"; also illustrations of the *Plasmodium tenue* of Stephens, and a plate illustrating Schaudinn's theory of parthenogenesis.

632. Cycles in the vertebrate hosts and in the mosquito are as follows:—

Cycle in vertebrates *(see screen illustrations)*:—Sporozoites inoculated in saliva of biting mosquitoes. Sporozoites invade red blood corpuscle. Growth at expense of cell (hæmoglobin absorbed and transformed into pigment in parasite). After two or three days, daughter-nuclei form (number varies with species); corresponding number of merozoites develop. Rupture of red cells. Merozoites in plasma (residual body with pigment phagocyted by leucocytes). Invasion of red blood corpuscles by merozoites. Schizogony repeated.

After several generations have been produced, certain merozoites, instead of developing into schizonts, become gametocytes (numerous pigment granules and single nucleus). The female or macro-gametocyte has a deeply-staining cytoplasm and compact nucleus. The male or micro-gametocyte has a faintly-staining cytoplasm and diffuse nucleus.

These gametocytes must die if they do not reach a mosquito's stomach.

633. Cycle in the Mosquito.

Further development of gametocytes will take place only in Anopheline mosquitoes in cases of human malaria, and Culicine mosquitoes in cases of bird malaria.

Red corpuscles in mosquito's stomach rupture by movement of gametocytes, which escape; during this process the pigment granules of the male are in a state of violent commotion. The process of breaking-up of nucleus, cytoplasm extrusion, etc., produces "flagellating body." The flagella-like structures are really microgametes which break loose and swim about, so that eventually one may come in contact with and fertilise a macrogamete, forming a motionless sphere or zygote. Soon this elongates and becomes motile, gliding about amongst the intestinal contents. The male and female nuclei approach one another and fuse. The vermicule then passes through the stomach wall until it lies just below the elastic membrane of the stomach, which takes part in the formation of the cyst wall. The nucleus of the zygote multiplies by repeated divisions.

The cytoplasm is reduced to a sponge-work of numerous anastomosing septa. Sporozoites are formed all over these cytoplasmic surfaces. Irregular masses of sporozoites may form *(see coloured photograph)*. Eventually the sporozoites break loose and lie within the cyst; they are about fifteen microns long.

The mature oöcyst now breaks and liberates the sporozoites into the body cavity or hæmocœle. They are motile and wander all over the mosquito's body, and may be found in any organ *(see illustrations)*. The majority come in contact with the salivary gland, which they penetrate, being finally ejected with the saliva when the mosquito bites.

Probably "black spores" are due to the death and degeneration of the oöcyst contents at various stages of development.

These are shown in the illustrations already mentioned; also in six coloured drawings (Wenyon's originals).

634. A painting is also shown of *Plasmodium falciparum* as seen in a spleen smear from a fatal case of malignant tertian malaria.

635. A large diagrammatic representation of the cycles in the human blood and in the mosquito is also shown.

636. Bass and Johns, in 1912, were the first to succeed in cultivating the malarial parasite. Illustrations are shown of their methods and results.

637. The development of the malarial parasite in the mosquito is also shown in a series of photo-micrographs by King.

638. Two illustrations by Mühlens show sporozoites in a palpus and in the scutellum of the mosquito.

639. Coloured photo-micrographs are shown in the special viewing-case, illustrating phases in the life-history of the malaria parasite, both in the mosquito and in man :—

(1) Benign tertian. Broken-up rosette. Two young forms in corpuscles. × 1000.

(2) Benign tertian. Two half-grown parasites and one earlier. × 1000.

(3) Benign tertian, showing half-grown parasite and Schüffner's dots. × 1000.

(4) Benign tertian. Commencing rosette formation.

(5) Benign tertian. Rosette. × 1000.

(6) Benign tertian. Gametocytes. × 1000.

(7) Quartan. Rings. × 1000.

(8) Quartan. Half-grown. × 1000.

(9) Quartan. Band form. × 1000.

(10) Quartan. Early rosette and fully grown. × 1000.

(11) Quartan. Rosette. × 1000.

(12) Quartan. Gametocytes.

(13) Malignant tertian. Ring forms. × 1000.

(14) Malignant tertian. Rosette and young forms. × 1000.

(15) Malignant tertian. Spleen smear ; young and fully grown forms, also early rosettes. × 1000.

(16) Malignant tertian. Crescents : male and female. × 1000.

(17) Section of human intestine showing numerous parasites in red blood corpuscles. Peripheral blood almost free. × 300.

(18) Same as last. × 750.

(19) Malarial brain. Section showing capillary blocked with *Plasmodium falciparum*.

(20) Benign tertian malaria. Flagellating body and leucocytes.

(21) Macro- and micro-gamete in stomach of mosquito, the latter possibly still attached to remains of crescent. × 1000.

(22) Benign tertian malaria. Sporozoites and residual body from cyst on stomach wall of mosquito.

(23) Section of stomach of *Anopheles maculipennis*. Cysts in wall. (Experimental). × 1000.

(24) Smear of salivary gland of mosquito, showing cell with sporozoites in and around. × 1000.

640. The Mosquito Host.

Wax models are shown illustrating *Anopheles costalis* (× 28), an important African carrier of malaria in all stages of development :—

(1) Egg.
(2) Larva.
(3) Pupa.
(4) Imago.

641. Illustrations are shown of various Anopheline eggs, also of methods of breeding and dissection.

642. In four illustrations are shown the differences between the Anopheline and Culicine mosquito, both in the developmental and adult stages.

643. Photographs by Marshall illustrate the following mosquitoes :—

(1) *Theobaldia annulata* (female).
(2) *Theobaldia annulata* (male).
(3) *Culex pipiens* (female).
(4) *Anopheles maculipennis* (female).

(It is the female alone who is responsible for infection).

644. A photograph by Marshall shows egg-raft and newly-hatched larvæ of *Theobaldia annulata*.

645. Exhibit of malaria-carrying mosquitoes :—

Europe : *Anopheles maculipennis.*
Asia : *Anopheles stephensi.*
Anopheles listoni.
Anopheles pattoni.
Anopheles maculipennis.
Anopheles culicifacies.
Africa : *Anopheles maculipennis.*
Anopheles funestus.
Anopheles costalis.
Australia : *Anopheles annulipes.*
North and South America : *Anopheles maculipennis.*
Anopheles tarsimaculatus.
Anopheles albimanus.

Breeding-Grounds of Mosquitoes :—

646. A series of six paintings is shown to illustrate the main divisions of such breeding-places :—

(1) Domestic.
(2) Woodland.
(3) Ponds and streams.
(4) Marsh-land.

Breeding-Ground : Refuse heap with tins.
,, ,, Water-tub.
,, ,, Tree-holes.
,, ,, Pond.
,, ,, Stream.
,, ,, Marshland.

647. A large number of photographs are exhibited, showing various breeding-grounds :—

Water barrel, unprotected and swarming with mosquito larvæ, Accra, Gold Coast. Presented by Sir William Simpson, C.M.G.

Bermuda : Heap of rubbish, behind which mangrove trees standing in swamp. From Lieut.-General Sir John Asser, K.C.M.G.

Food safe and anti-formicary, the latter full of Stegomyia larvæ. Port Louis.

Western Cemetery, Port Louis, Mauritius. Jars for flowers, breeding-places for mosquitoes.

Kuala Selangor, Federated Malay States, showing boat in the water in the hold of which *Anopheles ludlowi* were found developing. From Dr. A. R. Wellington.

Collection of odd water receptacles, the work of a few days, Bridgetown, Barbados. Boyce : " Mosquito or Man ? "

View in one of the Basra date groves, showing irrigation channels in the spills from which, at high river, *Anopheles (A. pulcherrimus* and *A. stephensi)* are found breeding.

Pools left after rain, Khartoum, Sudan. These were formed by a rainfall of 1·8 inches of one hour thirty minutes' duration. Some of these persisted for about three weeks.

" *Regard*," Port Louis, Mauritius. Breeding-place for Stegomyia. Crowds of larvæ in water in little hole.

Borrow-pits in pig village of Owusu. Report of the Medical Officer of Health, Accra, for the year 1922.

Rice fields with cottages. A typical mosquito-breeding area. From Dr. Minett, British Guiana.

Irregularly graded drain, showing pools receiving water from water stand-pipe, Freetown, Sierra Leone. Presented by Sir William Simpson, C.M.G.

Drain, showing stagnant pools, owing to want of proper grading and levelling, Freetown, Sierra Leone. Presented by Sir William Simpson, C.M.G.

A road culvert placed at too high an elevation to drain completely, a " man-made " mosquito-producing area. " Malaria and the Engineer," : published by the St. Louis S.W. Railway.

Grass fields near golf-course, showing stagnant drains on each side of railway. Presented by Sir William Simpson, C.M.G.

Mosquito Breeding-Places.—Flooded paddy fields (opposite the railway station). Water supplied from Wenaruwewa tank. This picture shows in the foreground pools formed by the hoof-marks of cattle, in which Anophelines breed. *After* Manson-Bahr. Permanently flooded paddy fields (on the Rajaphilla road). These fields are supplied by well-water and constitute a permanent breeding-ground of Anophelines. *After* Manson-Bahr.

Swamp region, near Butiaba, Lake Albert. Sir Andrew Balfour.

Brackish swamp at Roche Noir, separated from sea by ridge of sand; *Anopheles costalis* nursery in the summer.

Showing new village with pitch-hole on the edge of the lake in the foreground. Presented by Dr. E. de Verteuil.

Anopheline pools, Ceylon. Presented by Dr. Manson-Bahr, D.S.O.

Mosquito breeding-places, Southern Algeria. "Bull. Soc. Path. Exot.," Vol. V.

Mosquito breeding-places, Algiers. *After* Ross.

The danger of water in contact with new earth in the Federated Malay States. A breeding-ground of *Anopheles ludlowi*. From Dr. A. R. Wellington.

Actual breeding-places of Anopheline mosquitoes in the Eastern Transvaal. *After* Ross.

Ezra's Tomb, Tigris. The swamps at the back are a favourite breeding-ground of *Anopheles (A. pulcherrimus* and *A. sinensis)*.

Natural nullah in mountain stream, Hong Kong, showing formation of mosquito breeding-pools. Clark.

Rock pool in compound between dwelling-house and cess-pit. Presented by Sir William Simpson, C.M.G.

Actual breeding-places of Anopheline mosquitoes on the Crocodile River, Eastern Transvaal. Typical of many places along the river where the broken rocky ground holds many small pools after rain, or when the river is falling. *After* Ross.

The danger of water in contact with new earth in the Federated Malay States. Holes cut in alluvial soil near the coast for the reception of building foundations. Water contained therein soon became thickly populated with larvæ of *Anopheles ludlowi*, a noted fever carrier. Natural water on the surface (old earth) contained very few. From Dr. A. R. Wellington.

Fishermen's huts on Lake Langaza, a haunt of *Anopheles maculipennis*.

Views of various parts of Nefisha swamp near Ismailia. Breeding-place of *Anopheles (A. pharoensis)*. Part of filled-in area showing re-infiltration with water.

Thinned-out lotus water-bed, Palace Gardens. Bad breeding-ground. *Indian Medical Gazette*, December, 1914.

Mweera River, Zanzibar Protectorate, about seven miles from the town. In former days the seat of a district officer. Note the Government bungalow in close proximity to the river. Mosquito Brigade boy dipping for larvæ. The larvæ of *Anopheles funestus* abound in the sides of the river. From Dr. W. Mansfield-Aders.

Sebelini Kubwa Swamp, about two miles from Zanzibar town. A permanent breeding-ground of *Anopheles costalis*. Note the shallow edges and scrub, an ideal place for Anopheline larvæ. From Dr. W. Mansfield-Aders.

Portion of Monastir Swamp, showing pool in which larvæ of *Anopheles maculipennis* were found. All this part of the swamp was eventually drained. Photo by Captain Armour, No. 4 Canadian Hospital, Salonica.

Malaya.—Stream in hill land, in which *Anopheles maculatus* breeds. Watson.

Mangrove trees at Port Swettenham, amongst the reeds of which Anophelines breed. Watson.

View of lower part of Wady Kelt, formerly a breeding-place of *Anopheles palestinensis*.

View up stream of the Mweera river. The large plants with fleshy leaves at the side of the stream are a species of Colocasia. Between these plants the larvæ of *Anopheles funestus* are abundant. From Dr. W. Mansfield-Aders.

Sebelini Kubwa swamp. Taken from another point of view. Permanent breeding-ground of *Anopheles costalis*. In the foreground a member of the Mosquito Brigade dipping for larvæ. From Dr. W. Mansfield-Aders.

Pool under cliff at Cape Hellas, in which larvæ of *Anopheles palestinensis* were found.

Another view of the Mweera river. Boy hunting for Anopheline larvæ. From Dr. W. Mansfield-Aders.

Another view of ponds in Owusu, breeding *Anopheles costalis*, before being filled in. Report of the Medical Officer of Health, Accra, for the year 1922.

648. Paddy Fields under Water.

Planting out the Paddy. *Country Life*, 29th December, 1919.

649. The danger of clearing natural vegetation covering the wet inverts of valleys in Malaya. *Anopheles maculatus* breeds in pools and seepages of spring water exposed to the light, but avoids water in deep shade. From Dr. A. R. Wellington.

650. Silk Cotton Tree *(Eriodendron anfractuosum)* in flower, showing numerous parasitic "wild pines" in which the larvæ of five different species of mosquitoes were found. Boyce.

651. Tree Holes as Breeding-Places. Breeding-places, Grenada. *Bulletin of Entomological Research,*" Vol. VII, part 3.

(1) Hole in an Avocada pear tree, in which *Wyeomyia grenadensis* was breeding. In the fork of the tree is an ants' nest.

(2) Boulder stream in Grenada, which is exposed to the sun and swarms with Anopheline larvæ after flooding.

(3) Artificial hole in a mango tree, forming a breeding-place for *Megarhinus.*

652. Woodland Breeding-Places: Trees, etc. Boyce, "Mosquito or Man?"

(1) Water-holding and mosquito-breeding epiphytes upon a tree. Trinidad.

(2) Bamboo. The cut cane frequently holds water in which mosquitoes breed.

(3) An example showing how water-holding plants may act as mosquito breeding-places. Species of genus *Bilbergia,* in which larvæ and pupæ of *Scutomyia notoscripta, Stegomyia fasciata* and *Culex fatigans* have been noted. *Annual Report of Commissioner of Public Health,* Queensland, 30th June, 1914.

(4) Saman tree, covered with water-holding mosquito-breeding epiphytes *(Bromeliaceæ).*

(5) Example of water-holding tree. *Poinciana regia,* which has been prevented from further acting as a breeding-place of *Scutomyia notoscripta* by the deposition of cement in the cavity marked X. *Annual Report of Commissioner of Public Health,* Queensland, 30th June, 1914.

653. Specimen of Bromelia. Liable to hold water and form mosquito breeding-grounds.

Specimens

654. Model of eggs of Anopheline. N.B.—In ring are some eggs showing the actual size.

655. Model of Anopheline egg.

656. Model of raft of eggs of *Culicini.* N.B.—Floating loose are a few empty egg cases. (In ring are actual rafts.)

657. Larvæ and Pupæ of various *Culicidæ* :—

Toxorhynchites brevipalpis Theo. A predaceous larva.

Culex tigripes Grand. and Ch. A predaceous larva.

Culex fatigans Wied. The adult carries filariasis.

Anopheles costalis Loew. The adult is the chief malaria carrier of Africa.

Anopheles funestus Giles. The adult carries malaria in India, Burma, Ceylon and tropical Africa.

IV.—PATHOLOGY

658. Summary :—

Enlargement of the Spleen. In acute cases, it is soft and dark-red in colour ; in chronic infections, it is harder and may have a dark, steely-grey tint due to pigment. The liver is also enlarged, but to a less extent, and may be pigmented.

Blood thin and watery, number of red cells reduced out of proportion, surviving cells irregular in size and shape, and contain less hæmoglobin than normal. Leucopenia with increase of large mononuclears. Leucocytes pigmented. Capillaries of infected organs may show varying numbers of red cells infected with malarial parasites. Capillaries of the brain, spleen, intestine, liver or other organs, may be completely blocked by veritable emboli of infected cells *(see illustrations and colour photographs)*.

The following illustrations are shown of various pathological conditions :—

659. Confluent multiple punctiform hæmorrhages, due to *Plasmodium falciparum*. From Professor Dürck, 1917. Thrace. *(Copyright.)*

660. Multiple punctiform hæmorrhages in brain substance in a case of infection with *Plasmodium falciparum*. From Professor Dürck. *(Copyright.)*

661. Multiple punctiform hæmorrhages in cerebellum, due to invasion of *Plasmodium falciparum*, causing coma. From Professor Dürck, 1916. Üsküb.

662. *Plasmodium falciparum* invasion of cortex of cerebellum with cellular proliferation. From Professor Dürck. *(Copyright.)*

663. Blocking of a small vein of the cerebral cortex with shed endothelial cells and plasmodia. Malignant malaria. From Professor Dürck, 1916. Üsküb. *(Copyright.)*

664. Typical malarial nodule in the medullary substance of the cerebrum. "Daisy" figure formed by proliferation of glia-producing rod cells. From Professor Dürck. *(Copyright.)*

665. *Malaria.* Liver from a case of malaria of long standing. Endothelial cells and wandering cells in the capillaries are loaded with clumps of pigment. MacCallum : "A Text-book of Pathology."

666. *Malaria.* Capillary in the brain, filled with parasites of the æstivo-autumnal type. MacCallum : A Text-book of Pathology."

667. Illustration of section of brain, showing thrombosed vessels. Dudgeon : "Ophthalmological Society's Transactions," Vol. XLI.

668. Clumping of the malignant tertian parasite around a large mononuclear leucocyte. In culture forty-five hours. McLay.

669. Section of fibrous nodule on surface of human spleen, due to malarial perisplenitis. Mann's Stain. (× 26)

670. Section of malarial spleen, showing capillary blocked with parasitised corpuscles. (× 1500)

671. Malarial parasites in human brain—From Professor Plimmer's collection. Presented by Dr. W. Mansfield-Aders.

671A. Malignant tertian rings—From Professor Plimmer's collection. Presented by Dr. W. Mansfield-Aders.

672. Clumping of parasites around large mononuclear leucocytes, but not around the polymorphonuclear leucocytes (p). In culture thirty-four hours. McLay.

673. Section of cardiac muscle. Stained with Scharlach R. and hæmalum. Case of pernicious malaria, showing extreme degree of fatty degeneration of cardiac muscle. *Quarterly Journal of Medicine.* Vol. 12.

674. Splenic pulp in aestivo-autumnal infection, showing many pigmented parasites either free or enclosed in large phagocytic cells. MacCallum, "A Text-book of Pathology."

675. Section of brain from a case of malignant malaria :—

(1) Transverse section of capillary showing invaded corpuscles peripherally placed.

(2) Large blood vessel with no infected corpuscles.

(3) Longitudinal section of capillary.

(4) Oblique section of capillary.

676. Section of villus of human intestine, showing large infection of *Plasmodium falciparum* in blood corpuscles. Parasites were found in the peripheral blood only after very prolonged search in this case.

677. Eye changes in Malaria :—

Fig. 1. Shows a microscopical section of the optic nerve, with intravascular parasites.

Fig. 2. Shows a section of the retina, with a vessel containing infected red cells.

678. Splenomegaly (Malarial). Spleen removed from a Tartar, aged 16 years. Weight, 820 grammes. Size, $9'' \times 4\frac{1}{2}'' \times 2\frac{1}{2}''$. Kopylow. "Archiv. für Klinische Chirurgie."

679. Splenomegaly (Malarial). Spleen removed from a Tartar, aged 30 years. Weight, 2020 grammes. Size, $13'' \times 7'' \times 3\frac{1}{6}''$. Kopylow. "Archiv. für Klinische Chirurgie."

680. Splenomegaly (Malarial). Spleen removed from a man aged 50 years. Weight, 2880 grammes. Size, $13'' \times 7'' \times 2\frac{1}{3}''$. Kopylow. "Archiv. für Klinische Chirurgie."

681. Splenomegaly (Malarial) Spleen removed from a Turkish woman, aged 35 years. Weight, 1300 grammes. Size, $11\frac{1}{2}'' \times 6\frac{1}{4}'' \times 2\frac{1}{3}''$. Large cyst at lower border of front surface. Kopylow. "Archiv. für Klinische Chirurgie."

Pathological Specimens

682. Brain, from fatal case of cerebral malaria. Presented by Colonel F. P. Mackie, O.B.E., I.M.S.

683. Brain, from case of malignant tertian malaria. Cerebral vessels were found blocked with parasites. Presented by Dr. Lawrence G. Fink, Rangoon.

684. Brain, from case of subtertian malaria, showing hæmorrhage and capillaries blocked by parasites. Presented by Prof. L. S. Dudgeon, C.M.G., C.B.E.

685. Ruptured aortic aneurism, West African Native. This is a fairly common lesion among these natives. Presented by Dr. Scott Macfie, D.T.M.

686. Portion of intestine from fatal case of malignant malaria. Microscope slides show numerous parasites.

687. Liver in malignant tertian malaria. Presented by Dr. L. G. Fink, Rangoon.

688. Specimen of a ruptured spleen (Dr. Ingram's case). Presented by Dr. Scott Macfie, D.T.M.

689. Spleen, showing white patches and nodules. ? cause. Attributed to malarial perisplenitis. Presented by Dr. Scott Macfie, D.T.M.

690. Spleen, showing white patch. This condition is commonly found at post-mortems on West African natives and is attributed to malaria. Presented by Dr. Scott Macfie, D.T.M.

691. Malarial spleen. Presented by Dr. Minett.

692. Splenomegaly, the result of malaria. Note pigmented area at periphery. Red colour due to bad fixation. Presented by Dr. Bayon.

693. Malarial spleen. Presented by the Royal College of Surgeons' Museum.

694. Enlargement of Spleen—malaria.

V.—SYMPTOMATOLOGY

695. Summary :—

General Appearance.—In cold stage, pinched and blue face. In hot stage, flushed. In malarial cachexia, earthy colour with pigmentation. Herpes labialis and jaundice may occur. In chronic infection anæmia may be extreme *(see Paintings)*.

Temperature.—Cold stage, with temperature rising; hot stage, with temperature sustained for four to six hours. Rapid fall during sweating stage *(see Charts)*. In malignant tertian, a prolonged hot stage (fifteen to thirty-six hours) is a marked feature. The hyperpyrexial form may resemble sun-stroke.

Rapid pulse, nausea and vomiting are commonly present. Respiratory lesions and various skin eruptions may occur.

Nervous symptoms: coma, delirium, etc., occur in severe cases.

Some authors have recorded cases of multiple neuritis; that these are malarial in origin is doubtful *(see Illustrations)*.

Plugging of retinal arteries *(see Pathological Illustrations)* may lead to transient or lasting blindness.

The spleen is enlarged and painful *(see Specimens and Illustrations)*. Cachexia is frequently extreme.

Gangrene and ulcers of the extremities have been described, also stunting of growth due to prolonged infection *(see Illustrations)*.

696. Four coloured Temperature Charts show the stages of the parasite in relationship to the various phases of the attack.

696A. A series of Temperature Charts is also shown of all three varieties of the disease, and also of typhoid fever simulating malaria.

697. The following clinical illustrations are shown :—

Chronic malaria, showing enlarged spleen.

Case of chronic malaria, showing characteristic pigmentation. Dr. Manson-Bahr's case.

Malarial cirrhosis of liver, ascites and pellagra. From the Royal Society of Tropical Medicine and Hygiene.

Types of malarial cachexia. Deaderick.

Stunting of growth due to malaria. Age 18. Height: 1 m. 30. *Reforma Med.*, 12th March, 1922.

Stunting of growth due to chronic malaria. Age 24. *Reforma Med.*, 13th March, 1922.

Malarial ulcers in British Central Africa. David Kerr Cross: *Journal of Tropical Medicine and Hygiene*, November, 1900.

Malaria infected family. Rice report.

Chronic malaria in Paraná. *After* Araujo.

Chronic malaria cases, showing enlarged spleen. *After* Araujo.

Multiple gangrene in malaria fever. Osler: *Journal of Tropical Medicine and Hygiene*, December, 1900.

Polyneuritis of malarial origin. Rare condition. Mendelson: *Journal of Tropical Medicine and Hygiene*, 1st June, 1922.

Case of malaria in a child, showing emaciation, enlarged spleen and ascites. *After* Ruge and Verth. *Tropenkrankheiten und Tropenhygiene*. Vol. 6.

Malaria cachexia. Marked splenomegaly. *After* Leon.

698. Two Paintings are shown, illustrating the anæmic condition resulting from chronic malaria.

699. Four Temperature Charts of cases treated by Dr. Manson-Bahr, illustrate :—

(1) Benign tertian malaria.
(2) Quartan malaria.
(3) Subtertian malaria simulating typhoid fever.
(4) Inoculated malaria in a case of general paralysis.

700. Diagnostic illustrations are shown of the method of taking blood for making films and the preparation of thick films.

VI.—TREATMENT

701. Summary :—

Simple Benign Tertian or Quartan Attacks.

Wait until rigor and hot stages are over. When the skin is moist and temperature begins to fall, give gr. 10 of quinine, and then thrice daily after meals for a week.

If patient is constipated a saline purge should be given before the quinine.

To prevent recurrence, Manson-Bahr recommends a mild saline in the morning, and three 5-gr. doses of quinine during the day, once a week for two months. (The American standard treatment gives gr. 10 daily for two months.)

A tonic of iron and arsenic may be given after the first week.

If the sulphate is given in solution, it must have one minim of acid. sulph. dil. for each five grains.

Quinine hydrochloride is better ; it should be taken in water.

Toxic Effects of Quinine.—Singing in ears, visual disturbances, deafness, amblyopia, gastric and cardiac disturbances, syncope, urticaria.

Euquinine.—The ethyl carbonate of quinine is tasteless and effective.

Warburg Tincture.—An effective preparation. The dose is half an ounce, repeated after two or three hours.

Cinchona Febrifuge.—Is a preparation containing the total alkaloids extracted from cinchona bark. It is especially useful in benign tertian attacks owing to the high proportion of quinidine it contains. Issued by the Indian Government in 3-gr. tablets. Knowles gives it combined with alkaline treatment in gr. 10 doses three times a day.

Esanofele.—Is a proprietary preparation, much used in Italy. It contains quinine, arsenic and iron. The dose varies according to age from two to six pills a day.

Plasmoquin (Plasmochin).—Effective rapidly against all forms of the parasites except the subtertian schizont. All gametocytes—including crescents—are quickly killed. Occasionally produces a severe cyanosis ; this may be counteracted by combining with minute quantities of quinine. Hence Plasmoquin Compound is now used in tablet form, each containing 0·01 gm. of plasmoquin and 0·125 gm. of quinine. A very effective

treatment. Crescents disappear in three days. For an adult two tablets may be given three times daily for seven days, then four days' interval. Repeat course four times, and end with a seven days' course of one tablet three times a day. For infants, one tablet daily.

Stovarsol in 4-gr. tablets. Dose equals one to two tablets daily for ten days. Possibly the effect is chiefly due to the tonic action.

Treatment of Subtertian Malaria.

Mild cases as for benign tertian. Rest is of special importance. In endemic areas large doses of quinine may precipitate an attack of blackwater fever.

Intramuscular Injection of Quinine.

Sometimes painful and may be dangerous.

Indications: Inefficiency of oral administration, severe vomiting or gastritis, severe toxic or pernicious symptoms.

The bihydrochloride is the best salt of quinine to use.

A stout platino-iridium needle should be employed.

Solution freshly prepared and boiled. Needle and syringe sterilised.

Nine grains of quinine bihydrochloride in 1 c.c. of saline may be injected daily for three successive days. After injection, gentle massage is useful.

Intravenous Injection of Quinine.

In pernicious cases, where very rapid action is indicated, the bihydrochloride, gr. 10, in 10 c.c. of distilled water. Boil in a test-tube before use and inject into median basilic vein.

Inject slowly, taking at least three minutes over the 10 c.c.

The liberation of toxin may kill the patient; it is probably a good plan to give a small intramuscular injection first, and to follow it up in six or eight hours with a 6-gr. intravenous injection.

In cerebral malaria a 15-gr. dose may be given.

For Hyperpyrexia.

Cold bath, ice bag, etc. Give bath when temperature is 106° F. and stop at 102° F.

General.

Every case of malaria with fever should be nursed in bed. Subtertian infections should not be left alone, as they may become maniacal. Keep warm, change clothing when wet, give lemonade. Food: fluid and digestible. During convalescence, if patient has a good appetite, full diet.

Excretion of Quinine and the Picric Acid Method of Estimating Quinine in the Urine.

Two hundred c.c. of urine are acidified with a few drops of dilute sulphuric acid and boiled.

One to 1·5 grammes of dried picric acid are added to the hot mixture and stirred in. The whole is allowed to stand for at least one hour with stirrings at intervals. The liquid is then filtered through a filter paper of diameter not larger than $4\frac{1}{2}$ inches until the filtrate comes through clear. The filtrate must give no precipitate with a saturated aqueous solution of picric acid.

The precipitate and filter paper are transferred without washing to an Erlenmeyer flask, 50 c.c. of 3 per cent. caustic soda is added, and the whole heated on the water bath for half an hour with occasional shaking of the contents. The flask is cooled and the contents are transferred to a separate funnel and extracted three times with 50 c.c. of chloroform. The chloroform extract is collected in a flask and the chloroform is distilled off.

The residue is re-dissolved in dilute sulphuric acid. The solution is transferred to a separating funnel, is extracted twice with alcohol to remove pigment, is then rendered alkaline with 3 per cent. caustic soda and shaken out three times with chloroform.

The three chloroform extracts are run into a tared flask, the chloroform is distilled off, the flask dried at 120° C. to constant weight, and weighed. The residue is quinine together with any other alkaloids present in the urine.

Using the above method, Hele has determined the following points:—

(1) In health, quinine is eliminated more rapidly after oral than after intramuscular administration.

(2) The excretion rate of quinine in health shows no great fall from the second to the twelfth hour after an oral dose, from the fourth to the eighteenth hour after an intramuscular dose, and from the second to the twelfth hour after an intravenous dose.

It is suggested that the quinine concentration in the blood is relatively constant over the same periods. The excretion rate of quinine falls off rapidly after the first day. Elimination may continue for ninety-six hours.

(3) The excretion rate of quinine in malaria is similar to that in health, but there is greater variation after oral administration.

(4) The amount recovered from the urine varies from 10–30 per cent. of the administered dose.

(5) There is no evidence of any decrease of elimination during the course of the treatment.

(6) There is very little difference in the excretion of quinine in black-water fever cases.

(7) Only traces of quinine can be detected in the fæces. (Hele.) *Journal of the Royal Army Medical Corps*, April, 1922.

Two Photographs :—

702. Pelletier, Pierre Joseph, 1788–1842.
Isolated quinine, 1820, also strychnine, brucine and veratrine.

703. Caventou, Joseph Bienaimé, 1795–1877.
Isolated quinine, 1820, also strychnine, brucine and veratrine.

704. Production of Cinchona Bark.

The original source of supply of cinchona bark was South America, where the cinchona species are indigenous in the forests of the Andes between 10° N. lat. and 19° S. lat. Small supplies of bark are still obtained from these areas, though in comparison with the Java output it is quite insignificant. In the Imperial Institute Report, 1922, the total output has been recorded :—

Java	23,000,000 lbs.
India	2,000,000 lbs.
Other countries	400,000 lbs.

Cinchona bark of good quality is grown at St. Helena, and also in the Cameroons and East Africa. It seems likely that cinchona could be grown successfully on the hills of British Malaya.

705. Production of Quinine. Series of photographs.

Children " barking."

Weighing bark brought in from the plantation. Bark-drying shed in the background.

Portion of a ridge covered with *Cinchona Ledgeriana*. About six years old.

Cinchona Ledgeriana, probably about 7 or 8 years old.

Cinchona succirubra, probably about 9 or 10 years old.

A strip of bark being removed from a tree of *Cinchona Ledgeriana* for analysis of its quinine contents.

Part of a block of *Cinchona Ledgeriana*, showing six months' old plants.

Portion of a block of *Cinchona Ledgeriana*, showing plant of about 18 months old.

Portion of a block of *Cinchona Ledgeriana*, probably about five years old.

Young *Cinchona Ledgeriana* plants in a nursery line almost ready for planting out.

Transplanting seedlings in a nursery line.

Moderately distant view of a Cinchona nursery showing the shades from which the bamboo mats have been removed so as to allow the sun to get direct access to the young plants.

Exploration camp. Hunting for suitable sites.

Vegetation of the cinchona forests of Peru, with palms and tree-ferns. Lindley and Moore : " The Treasure of Botany."

Original forest before felling for clearing the ground for cinchona planting. A path cut through it.

Sowing cinchona seed in a nursery line.

706. A series of temperature charts after Rogers, showing the result of quinine treatment.

A series of exhibits demonstrating the production of quinine and Cinchona febrifuge. Samples of Cinchona preparations from Lieut.-Colonel A. Gage :—

707. Cinchona seed.

708. Inflorescence of various species of Cinchona.

709. Cinchona bark on trunk.

710. Ground Cinchona bark.

711. Oil from bark sludge containing the quinine and other alkaloids.

712. Quinine-bearing oil stirred with dilute sulphuric acid.

713. Acid liquors containing the quinine and other alkaloids.

714. Acid liquors treated with alkali to precipitate crude quinine sulphate.

715. Crude quinine sulphate.

716. Purified quinine sulphate.

717. Sulphate of quinine tablets ; $3\frac{1}{2}$ grains in each.

718. Cinchona febrifuge.

719. Cinchona febrifuge tablets ; $3\frac{1}{2}$ grains in each.

720. Residual alkaloids.

721. The wall-case also shows Cinchona and its alkaloids, illustrating various products which are employed in the treatment of malaria.

722. Tablets of " Plasmoquin Compound."

Each 0·01 gm. plasmoquin.
,, 0·125 gm. quinine sulphate.

Manson-Bahr states the clinical results are superior to plasmoquin alone, and the parasitotropic effect upon subtertian infections is increased, whilst the liability to cyanosis is avoided. For benign tertian and quartan malaria : for seven days, two tablets three times daily. Then four courses lasting one week each, with four days' interval, of six tablets daily. For subtertian malaria, the courses should be of five days each, with a four-days' break.

723. In a series of illustrations are shown the methods of injection of quinine and some of the harmful results (abscesses, ulcers, etc.). These are illustrated in two specimens. Badly prepared tablets may not be absorbed, as is seen in the tablets recovered from the stool of a man who was said to have quinine-resisting parasites.

724. A coloured drawing is shown to illustrate cyanosis resulting from treatment with plasmoquin.

725. An exhibit of Java Cinchona is shown illustrating the following varieties :—

Cinchona Ledgeriana.

Cinchona Ledgeriana.

Cinchona succirubra.

Cinchona hybrid *(Ledgeriana × succirubra ?)*

Cinchona hybrid *(Ledgeriana × succirubra ?)*

Cinchona succirubra (Pavon).

726. (*a*) Crude quinine from urine of malaria patient.

(*b*) Pure quinine base prepared from (*a*).

(*c*) Quinine hydrochloride prepared from (*b*). Presented by Professor J. G. Thomson.

727. Section of muscle showing necrosis due to intramuscular injections of quinine. Presented by Prof. Leonard S. Dudgeon, C.M.G., C.B.E.

728. Necrosis of gluteus maximus due to intramuscular injections of quinine. Presented by Prof. Leonard S. Dudgeon, C.M.G., C.B.E.

VII.—PROPHYLAXIS

729. Summary :—

The key-note to the spread and prevention of malaria is the incidence of breeding-places for the Anopheline carriers of infection.

Three stages in the life-history of Anophelines are spent in water : the egg, the larval and the pupal stages. By a careful study of the bionomics of Anopheline mosquitoes, it is possible to establish rational preventive measures, but it is essential that such investigations should be adjusted to the locality ; the habits of various species vary considerably, and financial considerations indicate measures which are directed against the *known* carriers of disease in the district.

Many methods of prevention are possible and careful selection must be made in accordance with local requirements. The use of larvivorous fish, combined with measures devised to assist their activities, such as removal of weeds, training of streams, etc., is effective in certain areas, whereas elsewhere drainage on a large scale may be indicated. The reclamation of swampy ground has also been found to be a valuable method of prophylaxis. Where such means cannot be adopted, the use of oil, or Paris green, may materially reduce the mosquito population. In any case in heavily infected areas personal prophylaxis with mosquito-nets, veils, gauntlets, mosquito-proof dwellings, etc., must be adopted.

The prophylactic use of quinine is under dispute, but it is probable that its regular use, though it may not prevent infection, at least reduces the incidence of the disease by destroying the parasites in the early stages of their infective activities.

730. A—Measures concerned with infected persons :—

(1) Isolation, mosquito nets, etc.

(2) Treatment.

(3) Anti-relapse measures.

B—Measures concerned with the transmitting mosquitoes :—

The adult insect : Hand-catching, spraying, fumigation, natural enemies—bats and birds.

The aquatic stages. Reclamation of marshland.

Forestry and deforestation.

Urban development.

Drainage :—

Underground drains.

Grouted ditches.

Vertical drainage.

Blind drains (filled with stones).

Open earth ditches.

Control of water by dykes and ditches.

Training of streams.

Re-grading.

Flushing of streams.

Avoidance or supervision of breeding-places produced by man :—

Borrow-pits.

Irrigation channels.

Pools.

Quarries.

Trenches and dug-outs.

Boats.

Barrels.

Broken-down guttering.

Refuse heaps with tins, etc.

Supervision of tree breeding-places :—

Cut bamboos.

Epiphytes.

Large leaves, etc.

Measures to make water unsuitable for breeding :—

Clearing of aquatic vegetation and weeds.

Concrete edging.

Constant agitation of water.

Natural enemies—fish.

To prevent mosquitoes ovipositing :

Screening of receptacles.

Oiling and poisoning :

Paris green, etc.

The Susceptible Person.

Maintain general health. Avoid undue exposure, fatigue, etc.
Segregation of infected natives.
Nets, gauntlets, etc.
Screened houses.
Quinine prophylaxis.

731. A series of paintings illustrate the various methods of prophylaxis :—

Education.
Investigation to discover breeding-grounds.
Patient protected by mosquito net.
Removing undergrowth.
Fumigation to destroy mosquitoes.
Destruction of mosquitoes—traps.
Oiling ponds.
Stocking water with larvivorous fish.
Training streams.
Flushing of streams.
Filling in swampy plain.
Road-making.
Screening water-tubs.
Repairing guttering.
Mosquito net.
Mosquito-proof dwellings.

Natural Enemies

732. A series of paintings, photographs and half-tone reproductions illustrate the natural enemies of mosquitoes. The most important of these are the larvivorous fish of which many specimens are shown :—

733. Sticklebacks—of value for fighting against salt-water breeding mosquitoes. Presented by Surgeon-Commander David Given, R.N.

734. Shrimps—of value for fighting against salt-water breeding mosquitoes. Presented by Surgeon-Commander David Given, R.N.

735. *Haplochilus bifasciatus* Stdr. Larvivorous fish from the Anglo-Egyptian Sudan. Presented by Major R. G. Archibald, D.S.O., R.A.M.C.

736. *Haplochilus kingi* Boul. Larvivorous fish from the Anglo-Egyptian Sudan. Presented by Major R. G. Archibald, D.S.O., R.A.M.C.

737. *Haplochilus marni* Stdr. Larvivorous fish from the Anglo-Egyptian Sudan. Presented by Major R. G. Archibald, D.S.O., R.A.M.C.

738. *Haplochilus playfairi*. From Zanzibar. These fish eat mosquito larvæ and are of great use against Anophelines. Presented by Dr. W. Mansfield-Aders.

739. *Tilapia melanopleura*. Larvivorous fish from the Gold Coast. Presented by Dr. J. F. Corson, D.T.M. & H.

740. *Haplochilus sexfasciatus*. Larvivorous fish from the Gold Coast. Presented by Dr. J. F. Corson, D.T.M. & H.

741. *Barbus trispilus*. Larvivorous fish from the Gold Coast. Presented by Dr. J. F. Corson, D.T.M. & H.

742. *Barbus ablabes*. Larvivorous fish from the Gold Coast. Presented by Dr. J. F. Corson, D.T.M. & H.

743. *Tilapia zillii*. Larvivorous fish from Sekondi. Presented by Mr. Abbott.

744. *Haplochilus, sp.* Larvivorous fish from Sekondi. Presented by Mr. Abbott.

745. *Mugil falcipinnis*. Larvivorous fish from Sekondi. Presented by Mr. Abbott.

746. *Pseudomugil signifer* Kner. The "Blue Eye." A larvivorous fish from Australia. Presented by L. E. Cooling.

747. *Melan. nigrans*. A larvivorous fish :—

748. (1) *Rivulus harti*.
(2) *Girardinus guppyi*.
(3) *Pœcilia unimaculata*. Larvivorous fish.

749. Indian Larvivorous Fish. Presented by the Indian Museum, Calcutta :—

Anabas scandens (Daldorf).
Macrones vittatus (Bloch).
Ophiocephalus gachua (Ham. Buch.).
Panchax panchax (2) (Ham. Buch.).
Trichogaster fasciatus (Bl. Schn.).
Trichogaster fasciatus (Bl. Schn.).
Trichogaster labius (Ham. Buch.).
Ambassis nama (Ham. Buch.).
Ambassis nama (Ham. Buch.).

Ambassis ranga (2) (Ham. Buch.).

Barbus ticto (Ham. Buch.)

Barbus ticto (Ham. Buch.).

Barbus chrysopterus (McClelland).

Nuria danrica (Ham. Buch.).

Badis badis. (Ham. Buch.).

750. *Anabas scandens* (climbing perch). Habitat: Western and Eastern Africa, India and China. Used in anti-mosquito work.

751. *Trichogaster fasciatus.* Habitat: South-Eastern Asia and Africa. Used in anti-mosquito work. These fish are active destroyers of mosquito larvæ and pupæ.

752. *Haplochilus panchax.* Larvivorous fish from Federated Malay States. Caught by Mr. C. N. Maxwell. Presented by Dr. A. R. Wellington.

753. *Haplochilus javanicus.* Larvivorous fish from Federated Malay States. Caught by Mr. C. N. Maxwell. Presented by Dr. A. R. Wellington.

754. *Lebistes reticulatus.* Habitat: the Tropics and sub-tropical regions. Used in anti-mosquito work.

755. *Girardinus reticulatus* ("Millions"). Imported to Guayaquil from Trinidad for anti-stegomyia work. Presented by Dr. Pareja.

756. *Gambusia nicaraguensis.* Known as "Pupos" in Coatepeque and "Quixque" in Mazatenogo, Guatemala. Presented by Dr. John E. Elmendorf, Junior.

757. *Polycentrus schomburghii.* Larvivorous fish from the Pitch Lake, Brighton, Trinidad. From Mr. Urich.

758. *Rivulus harti.* Larvivorous fish from the Pitch Lake, Brighton, Trinidad. Presented by Mr. Urich.

759. *Pœcilopsis lutzi* (Zambucos). From Zacapa, Guatemala. Presented by Dr. John E. Elmendorf, Junior.

760. Three species of larvivorous fish from Honduras:—

Tetragonopterus aeneus (Günth). Characidæ. Locally known as "Billham."

Mollienisia sphenops (Cuv. and Val.). Cyprinodontidæ. Locally known as "Poopsey."

Cichlasoma otofasciatum (Regan). Cichlidae. Locally known as "Grana."

" Billham " and " Crana " are of value for use in cisterns and vats ; " Poopsey " is too delicate a fish for cisterns, but makes a splendid top minnow for pools, trenches, shallow wells and running streams. Presented by Mr. John Peach.

761. *Fundulus bermudensis*. A larvivorous fish from Bermuda. From Sir Andrew Balfour.

762. Chara, *sp*. Water-weed which is stated to prevent mosquito-breeding. There is considerable doubt as to its efficacy.

763. *Priopis olivaceus*. Larvivorous fish.

DRAINAGE

764. Illustrations :—

(*a*) " Herring-bone " drainage of swamps.

(*b*) " Herring-bone " drainage of a bog at the out-crop of a hill stream. This valley was, previous to drainage, a profuse breeder of *Anopheles maculipennis*. Presented by Major A. Oliver, R.A.M.C.

General view of ravine showing drainage by concrete and rubble drain, and in the distance subsoil clay pipes being laid in a contour drain. From Dr. A. R. Wellington.

Malaya :—

(*a*) Subsoil pipes emptying into open drain.

(*b*) New type of permanent drain into which subsoil drains discharge. Watson.

Anti-malaria drainage in a rubber estate. A valley with subsoil drains underneath, showing the dams made to break the force of storm water.

Subsoil pipes for laying. Malaya. From Dr. A. R. Wellington.

Central drain and rubble herring-bone lateral drain. From Dr. A. R. Wellington.

Anti-malarial works. Pipe draining at Tapah, Federated Malay States, showing :—

(*a*) The trench, five feet deep ; a shallower depth would result in the pipes becoming blocked by grass roots.

(*b*) Baked clay pipes placed end to end.

(*c*) Palm leaves to cover pipes and prevent the silt from blocking them before the filling solidifies.

(*d*) The banked-up earth which will fill the trench above the layer of palm leaves. Work planned and carried out by Mr. E. D. Kibble, of the Federated Malay States Public Works Department. From Dr. A. R. Wellington.

Anti-malarial work, Kuala Lumpur. Showing blockage of pipes by grass roots, the result of laying pipes less than three feet below the surface. From Dr. A. R. Wellington.

An excellent gang in a soft place. Shows the kinds of spades used. Report of Entomological Department, The New Jersey Agricultural Experiment Station, 1904.

Land cleared of trees ready for ditching with dynamite.

A typical ditch, made with dynamite, through the same character of land as shown in the photograph above. "Malaria and the Engineer." Published by the St. Louis S.W. Railway.

A typical city stream before ditching and clearing of vegetation.

The same stream after ditching and clearing. "Malaria and the Engineer." Published by the St. Louis S.W. Railway.

Machine ditch, showing how the whole sods, 30 × 6 × 10 inches each, are laid in series along the ditch. Report of the Entomological Department, The New Jersey Agricultural Experiment Station, 1904.

Machine-cut ditch, 10″ × 30″ deep. Darnall, *Journal of the American Medical Association*, September, 1919.

Rear view of the ditching machine, shows how the sod is taken up and drawn to one side. Report of Entomological Department, The New Jersey Agricultural Experiment Station, 1904.

The True ditching machine at work on the Newark Meadow. Report of the Entomological Department, The New Jersey Agricultural Experiment Station, 1904.

A gate to impound water for flushing a ditch. "Empire." Le Prince and Orenstein.

Removal and destruction of larvæ and matted algæ in a ditch by flushing. "Empire." Le Prince and Orenstein.

Kapar drainage scheme. Main drain, with rubber trees on both sides. Watson.

Malaya. Drains in which *Anopheles ludlowi* does not breed. Watson.

A main drain at Klang, with concrete invert and turf. Top sides made in 1902. Watson.

Toro Point drainage system. Upper end of drain No. 4, June, 1911.

Types of drain recommended for anti-malarial work. From Dr. A. R. Wellington.

Concrete drain after construction. Note depth of filling. Report of the Medical Officer of Health, Accra, for the year 1922.

Another portion of drain. Area not completely levelled. Report of the Medical Officer of Health, Accra, for the year 1922.

Tidal gate :—

(*a*) Deep drain rendered possible by tidal gate. Watson.

(*b*) Automatic tidal gate on Carey Island. Watson. Report of the Medical Officer of Health, Accra, for the year 1922.

765. (*a*) Clairfond Marsh, Mauritius, 1908, showing the spleen index.

Explanatory note: Clairfond is 1400 feet above sea-level, and at this time severe malaria was very prevalent in the marsh and surrounding district. Blackwater fever also occurred. Thus, during the first seven weeks of 1908, there were 87 admissions for malaria fever from Vacoas Barracks out of a strength of about 900. These were nearly all virulent subtertian; five of the 87 died, and over 40 of the remainder had to be invalided to England. Distance from the nearest piece of marsh to the nearest barrack-room, 850 yards.

Local carrier—*Anopheles costalis*.

(From "Malarial Investigations," Mauritius. Fowler.)

(*b*) Clairfond Marsh, Mauritius, 1912, showing the spleen index.

Explanatory note: Clairfond Marsh was drained in 1907–1908, at a cost of £2200. In 1912, the "marsh" was represented only by a few well-canalised streams. Both malaria and blackwater fever had absolutely disappeared. None of the troops contracted malaria in Vacoas during 1912–1913–1914.

(From the Sanitary Report, Mauritius Command, 1912. MacArthur.)

766. Malaria Control at Nitrate Plant.

A pond of more than 40 acres at Sheffield, Alabama, drained by a 41-feet vertical shaft. *Engineering News Record*, Vol. 82, No. 15.

766A. Breeding-Places, Mauritius. Ross.

The cause of malaria among the troops in the huts.

This stream was situated at a distance of 400 yards, and formed a most favourable breeding-ground for *Anopheles costalis*.

Indian village in the middle of a marsh, Clairfond, Mauritius.

Spleen rate of children, 96 per cent. Barracks (native), 400 yards distant. Barracks (European), 1000 yards distant. Malaria very prevalent amongst the troops.

A native hut in the same village.

Showing how it was surrounded by marsh. Anopheline larvæ swarmed here.

Anopheline breeding-ground in a Colonial Cantonment, Mauritius.

Part of an old trench fortification and moat near Port Louis, Mauritius.

Anopheles costalis larvæ were swarming among the grass. Malaria very prevalent in the barracks situated about 900 yards away.

Clairfond Marsh in Mauritius, with village near by.

Malaria rife among troops in barracks situated at several hundred yards distance.

Training of Streams

767. A series of photographs dealing with the training of streams :—

Canalised river, Black River District, Mauritius.

Canalised river, Leche Flacq, Mauritius. From Sir Andrew Balfour.

Canalised mill stream, Monastir Swamp. There are pools infected with Anopheles larvæ amongst the reeds alongside the stream. Photo by Capt. Armour, No. 4 Canadian Hospital, Salonica.

Canalising a gravelly and rocky part of a stream. Walls of the canal are built of the stones got by blasting the passage. Presented by Major Archibald Oliver, R.A.M.C.

Anti-malarial operations in the valley between Ramleh and Jerusalem. From Sir Andrew Balfour.

Vegetation removed from the edge of a pond at Bohio.

Removing vegetation from overgrown streams ; matchets are used. Le Prince and Orenstein.

Ditch cleared by hand labour, showing condition two months after removing grass.

Burning grass from side of ditch ; crude oil used as fuel.

Condition of ditch two months after burning. Le Prince and Orenstein.

Drain before being prepared. Presented by Dr. E. de Verteuil.

Preparation of drain to be lined with liquid asphalt. Presented by Dr. E. de Verteuil.

Burning liquid asphalt with sanitary oil spray. Presented by Dr. E. de Verteuil.

Completed drain lined with asphalt, two months after, showing pieces of barrel hoops in position. These are driven in flush with the surface, or removed immediately after burning. Presented by Dr. E. de Verteuil.

Oiling

768. A series of photographs and half-tone illustrations dealing with the process of oiling :—

"Filming" a ditch with paraffin by means of "one-handed" pneumatic sprayer.—*Health*, 5th November, 1921.

Cresol dip over irrigation channel. Mauritius.

Weed-covered reach and pool of the Gerasini stream, to show difficulties in oiling. From Sir Andrew Balfour.

Method of spraying larvicide or oil on pools so as to prevent mosquito production. "Malaria and the Engineer." Published by the St. Louis S. W. Railway.

An automatic oiler for cesspools. Described in the "Annals of Tropical Medicine and Parasitology," Vol. I. By E. H. Ross and H. C. Ross.

Type of oil sprayer and jacket used. Malaria control. A demonstration of its value to railroads based on experience of the St. Louis S. W. Railway Lines.

Spraying oil on a pond that could not be drained. Malaria Control. A demonstration of its value to railroads based on experience of the St. Louis S. W. Railway Lines.

Apparatus for oiling under pressure.

Scene on Golden Bridge Pond, showing type of lake margin treated. Reproduced from Public Health Bulletin, No. 156, Washington. (Griffith's Paper).

Oil cart for applying oil to roadside ditches.

Algæ united with oil in mat-like masses. " Empire."

Oiling obstructed streams on cut-over lands.

Field supply tank.

Pack mules, for oil transportation in jungle trails.

The larvicide plant at Ancon.

Application of larvicide or oil by knapsack sprayer. Miraflores.

Oil drip applied to hillside stream.

Oiling of breeding-places along a river bank.

Brush in valley of Pedro Miguel River. Some Isthmian topographical conditions increased the cost of transportation and treatment to several times the initial value of the oil. Le Prince and Orenstein.

Personal Measures

769. A series of photographs dealing with personal prophylaxis :—

Draught from propeller as deterrent to mosquitoes.

Screened cars in railroad construction camp.

Types of screened houses, Culebra.

Screened verandahs, Ancon.

A good device to prevent the sagging of screened doors.

Diagrams showing best locations for screen doors.

Screened vestibule door.

Types of screened houses, Colon Hospital Grounds.

Bungalow showing mosquito protection, Araujo. A prophylaxia Rural no Estado do Parana.

Railway windows and doors screened to keep out mosquitoes. " Malaria and the Engineer."

The non-inflammable " mosquinette " with smoker.

Shorts with flaps for protecting knees.

Mosquito net for head and neck. Brighton, Trinidad, near Pitch Lake. Dr. George.

Mosquito boots.

Gloves for protection of wrists and arms.

Mosquito net with canvas protection to lower part.

Another form of net for head protection.

Mosquito protection, showing gauntlets, flaps to shorts and hood.

Mosquito net for head and neck. Brighton, Trinidad, near Pitch Lake.

Prevention of Malaria. The mosquito net properly fitted up.

Mosquito net hammocks, Upper Orinoco. Hamilton Rice.

Mosquito-proofing hammock. Padwick. *Journal of the Royal Naval Medical Service*, April, 1922.

Issue of prophylactic and curative quinine to refugees from Asia Minor. Salonica.

Quinine prophylaxis card as used in Salonica.

Buffalo stable for protecting human dwellings from anopheline invasion. Schüffner. *Report of the Dutch Indian Medical Civil Service.*

Anti-malarial work, Tapah, Federated Malay States. From Dr. A. R. Wellington.

Prince Boris' Tent. Dr. J. A. Turner. Presented by Dr. Newnham, C.M.G.

A coolie " range " showing the water barrels ; they are all screened. Sugar Plantation, Diamond, Demerara.

A properly screened water barrel on Plantation Diamond, British Guiana.

Yards in Leopold Street, Georgetown, Demerara, showing wooden vats. Boyce, " Mosquito or Man ? "

Water barrel screened with mosquito-proof wire. Inexpensive and efficient. Dickson.

Water storm board, replacing gutter. Civil Prison, Port Louis.

Cleaning cots for labourers, Camp Rio Grande.

Stations on railway between Tiflis and Baku showing malaria towers. From Dr. C. M. Wenyon, C.M.G., C.B.E., F.R.S.

Protected fountain. Turner, " Sanitation in India."

Street " stand-pipe," showing benching. " Tropical Sanitation."

The Uses of Paris Green in Malaria

770. Photographs presented by Dr. L. W. Hackett.

Use of a boat in treating large areas of aquatic vegetation with Paris green larvicide. Ditches can be treated as fast as a man can walk

Knapsack blower used for dusting water surfaces with Paris gree larvicide mixture.

Apparatus for mixing road grit and Paris green.

Consists of double cylinder of wire-screen, the inner cylinder of heavy iron-wire and coarse mesh, the outer cylinder of fine copper screen, diameter 24 cm. Length of the cylinder 55 cm. over all; it revolves on a central axle, one end being placed 3 cm. higher than the other.

Typical method of spreading Paris green mixed with road dust as a larvicide.

Apparatus for sifting road-dust or other materials to mix with Paris green for use with blowers.

Marshes and extensive water surfaces may be dusted by hand.

Knapsack sprayer for larvicidal mixture.

Apparatus for sifting road grit for mixing with Paris green.

Knapsack sprayer for larvicidal mixture.

Exhibits Dealing with Preventive Measures

771. Mosquito-catching tube. Presented by Dr. L. W. Hackett.

772. Special apparatus invented by Dr. Hackett for staining blood films in bulk. Presented by Dr. L. W. Hackett.

773. Glass receptacle for catching mosquitoes. Presented by Dr. L. W. Hackett.

774. Special form of dipper for collecting mosquito larvæ, used by Dr. Hackett in his anti-malarial work in Italy. Presented by Dr. L. W. Hackett.

Paris Green

775. Crude road dust.

776. Screened road dust.

777. Paris green.

778. Larvicide mixture.

779. Bellows for spraying Paris green.